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Bridging the Gap Between Lab Scale and Full Scale Catalysis Experimentation

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Introduction

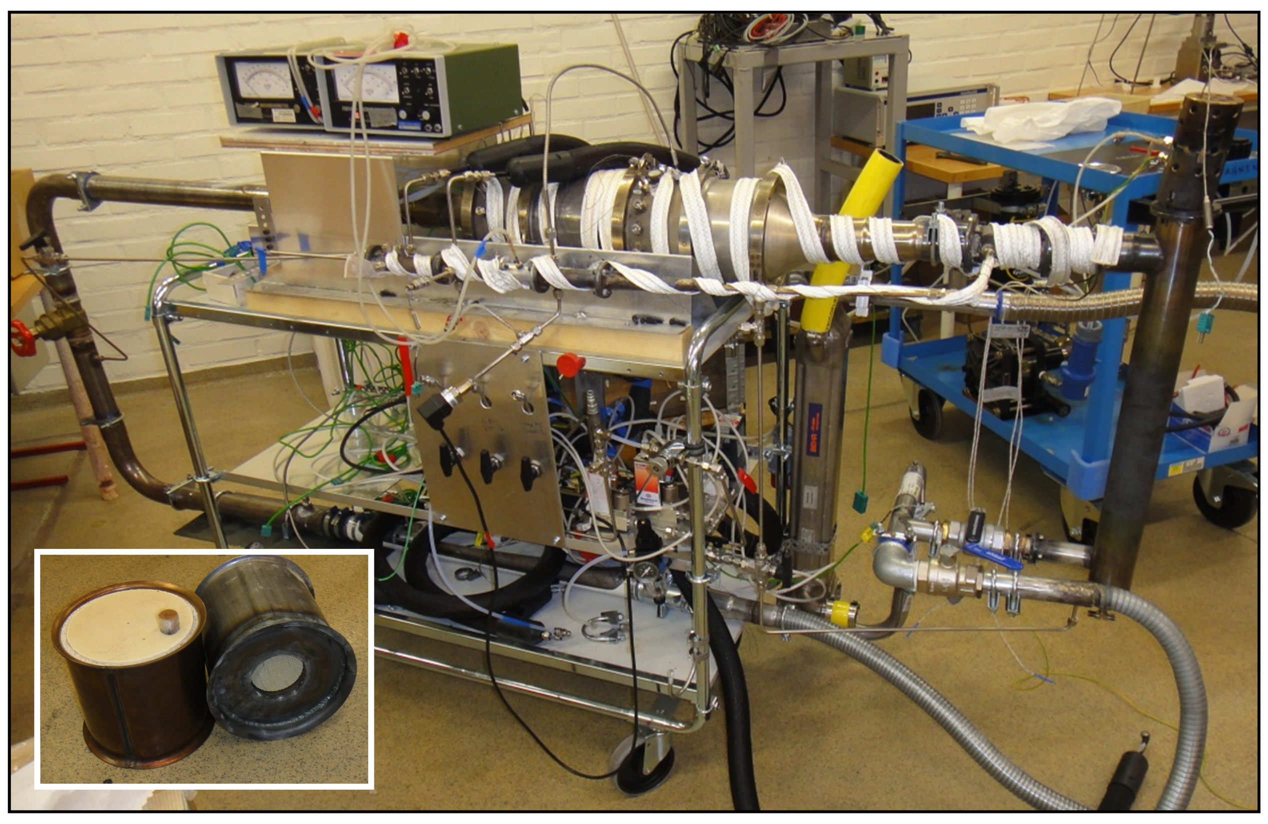
The knowledge transfer between lab scale and full scale is becoming increasingly important.

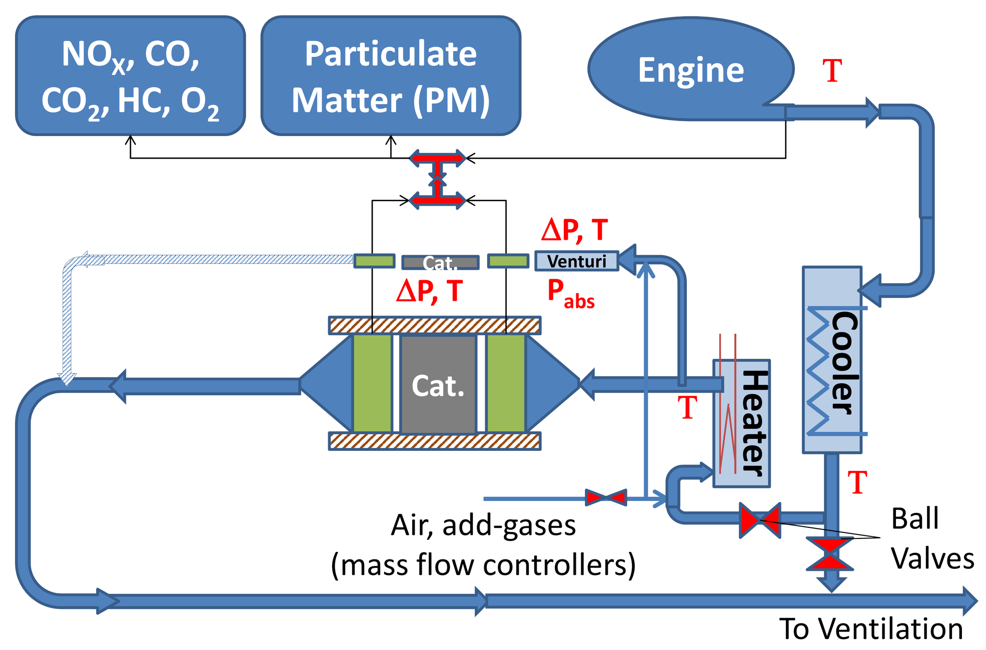
Lab scale understanding of complex catalytic phenomena needs to be transferred to full scale with high precision.

Real world issues need to be revisited in more fundamental studies

Objective

To develop a reactor system (EATS, Emission Aftertreatment System) that creates a bridge between lab scale and full scale research experimentation.





EATS experimental features

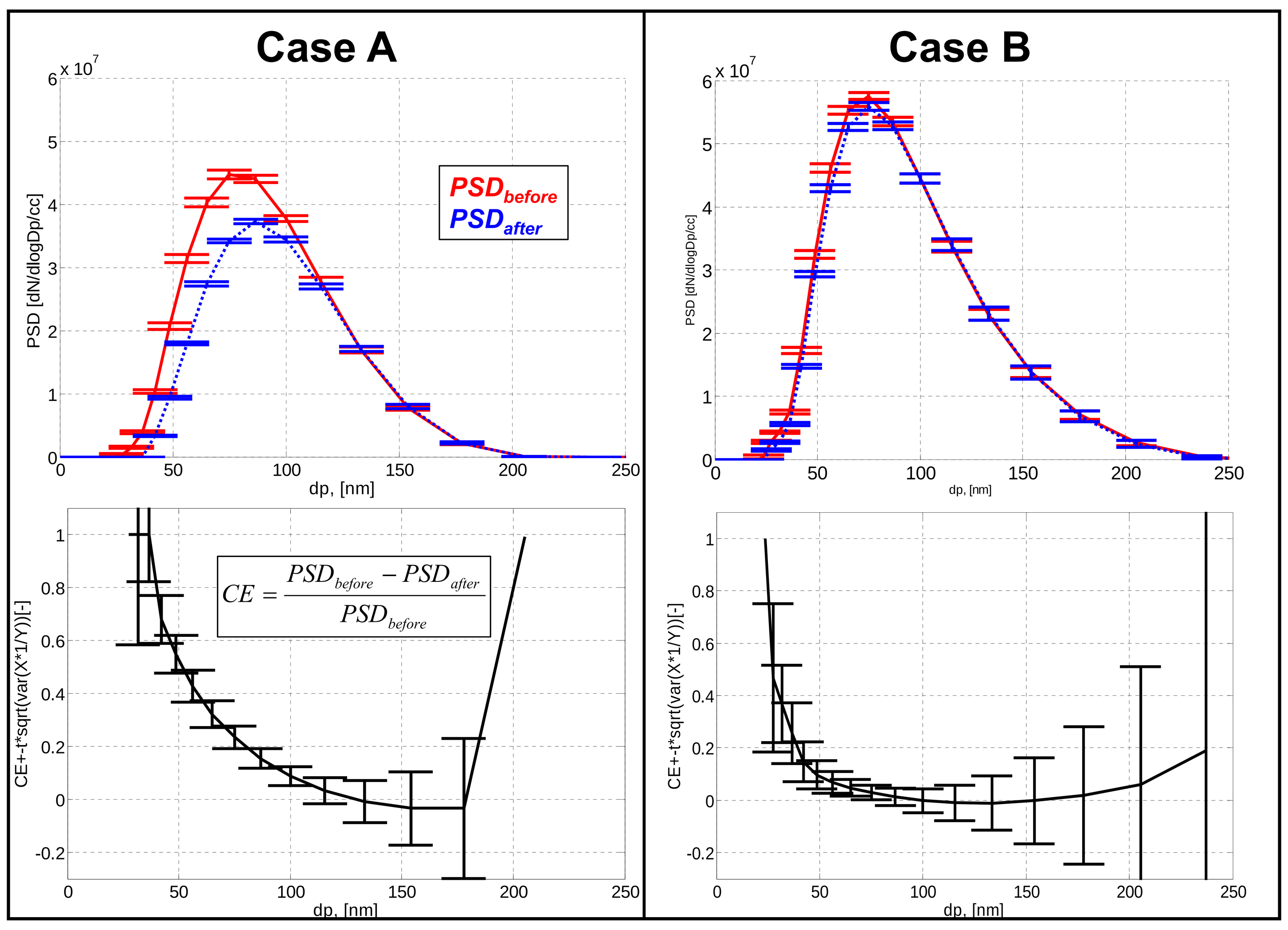
Highly flexible
- Different engine type, size
- Two "legs" (0.2-20 l/min or 10-1000 l/min)
- Different catalyst sizes

Independent residence time
- Set by flow by-pass (ball valves)
- Measured by pressure drop or venturimeter

Independent concentrations
- Added air or synthetic gases
- Mass flow controllers (Labview)

Independent temperatures
- Cooler & heater
- "Adiabatic" heating tape

Example 1: Particulate Matter (PM) Capture



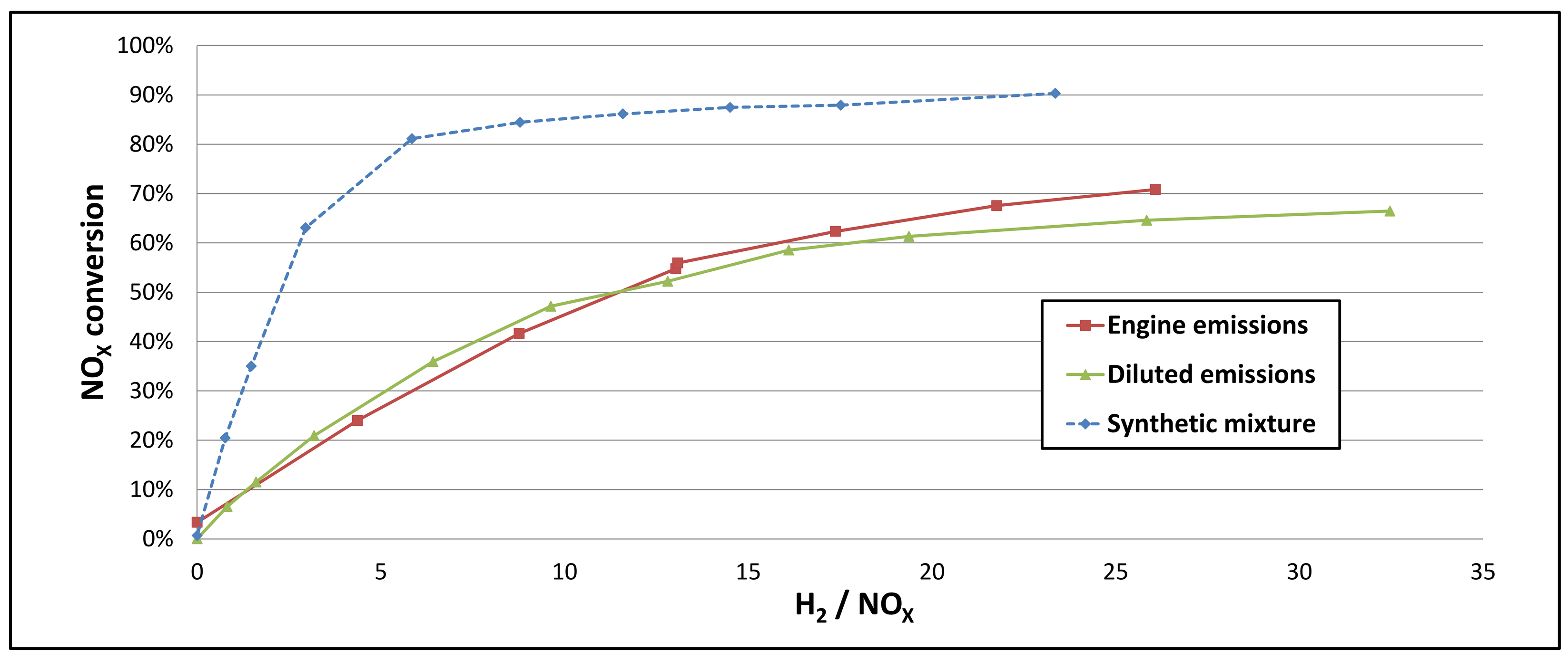
Engine: 5 cyl (2.4 dm³), Low sulfur diesel fuel (MK1), 1200 rpm, 30 Nm (BMEP=1.57 bar)
Substrate: Bare ceramic monolith (5.66" x 6", 400 cpsi, 2.5 dm³)
PM instrument: DMS 500, 1dil=1:1, 2dil=100:1, $T_{sample\ line}$=75 °C, $P_{instr.}$=0.25 bar

PM capture conditions	T_{cat} [°C]	T_{min}/T_{max} [°C]	Flow [Nl/min]	$Re_{channel}$ [-]	N (data points before/after)
Case A	222	194/258	66	2.7	185/197
Case B	157	154/159	210	10.8	62/110

Results PM Capture
- Low flow required to get significant capture
- Capture efficiency (CE) depend on reactor conditions (T,Q)
- Uncertainty for CE depends on signal level as well as secondary effects (PM, flow properties, sampling procedures)

Significance
- Important to measure accurately and representatively
- Secondary effects apparent when comparing with simulations (on-going work)

Example 2: H_2-assisted NH_3-SCR over Ag-Al_2O_3



Engine: 1 cyl (0.48dm³), Diesel fuel (MK1), 1200 rpm, 14.7 Nm (BMEP=3.85 bar)
Catalyst: 2x2 cm (6.28 cm³), Ag/Al_2O_3: 2 %w/w (freeze-dried Sol-Gel preparation)
Add-gases: NH_3(4 % in N_2), H_2 (40 % in He), compressed dry air for diluted emissions and NO (900 ppm in N_2) for synthetic mixture

Inlet conditions	T_{cat} [°C]	Flow [Nl/min]	NO_X [ppm]	NH_3 [ppm]	H_2O [%]	CO [ppm]	CO_2 [%]	"Diesel" (C_1)[ppm]
Engine emissions	255	1.6	548	451	3.5	150	4.2	56
Diluted emissions	256	1.6	376	264	3.0	102	2.8	52
Synthetic mixture	252	0.6	293	234	0	0	0	0

Results Ag-Al_2O_3 SCR
- Same H_2 effect upon dilution if conversion evaluated as H_2 to NO_X ratio
- Synthetic mixture had different residence time, which affects both NO_X conversion and un-selective H_2 reactions

Significance
- Same catalyst evaluated at both lab scale and engine conditions
- Important comparison with lab scale results (on-going work)

Conclusions

The EATS enables experimentation that is **not possible** using traditional methods.